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THE 81st REPORT OF THE STATE GEOLOGIST 1988-89

CALIFORNIA
DEPARTMENT
OF CONSERVATION
Division of Mines and Geology

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(1) Cover: Understanding and classifying sources of mineral resources is necessary for prudent land-use planning today and in the future. DMG classification projects provide such information in many portions of the state. Collection of new data in the field is crucial to classification. Two DMG geologists plan a day of classification work in the field.

THE 81st REPORT OF THE STATE GEOLOGIST 1988-1989

NEW INITIATIVES IN SEISMIC SAFETY AND MINERAL POLICY

California Department of Conservation
Division of Mines and Geology
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(2) DMG traveling exhibits provide opportunities for Division outreach at conferences and county fairs. DMG staff member explains seismic safety points at the Earthquake Preparedness exhibit during April. *Photo by M. Flanery, DMG.*

(3) DMG exhibit at the California Science Teachers' Association conference in Sacramento. About 800 science teachers attended the meeting. *Photo by M. Flanery, DMG.*

FOREWORD

The purpose of this Annual Report remains the same as in earlier years — to provide the Governor's Office, the California Legislature and the public with an understanding of the accomplishments of the Department of Conservation's Division of Mines and Geology. In this report, however, I am highlighting initiatives which began in 1988-89 as part of our continuing effort to achieve greater outreach to those who rely upon our information and services in the areas of seismic safety and mineral policy.

Not all of these initiatives could be carried to completion during 1988-89. Nevertheless, this report demonstrates how our 110-year-old organization is committed to meeting California's needs today. The Division is engaged in continuing to emphasize communication with its diverse user constituencies.

James F. Davis
State Geologist

(4) Publications are an important means of DMG communication. Publications can be examined and purchased at the DMG office in Sacramento and at the publications and information desks at DMG Offices in Los Angeles and Pleasant Hill. *Photo by M. Flanery, DMG.*

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TABLE OF CONTENTS

Executive Summary vii

Introduction xi

PART I SEISMIC SAFETY INITIATIVES 1

Understanding Earthquake Ground Motions and How They Damage Structures 2

Achieving More Earthquake Resistant Hospital Designs in California 6

Feasibility of an Earthquake Warning System in California 7

PART II MINERAL POLICY INITIATIVES 11

New Land Uses for Old — Mined Land Reclamation 12

Mining Waste — Development of Compatible State and Federal Regulations for Assuring Environmental Quality in California 16

Creating an Active Mines List — Communications Networking between Federal, State, and Local Governments and the Mining Industry 21

Prudent Policies Regarding California's Mineral Endowment 23

Conclusion 28

(5) Earth science teachers' meetings, such as the California Science Teachers' Association meeting held in Sacramento, provide an opportunity to distribute DMG publications. Knowledge of local geology helps teachers bring the subject to life for their students. *Photo by M. Flanery, DMG.*

EXECUTIVE SUMMARY

The geology of California is at once the source of both opportunities and challenges. During its 110-year history, the Division of Mines and Geology (DMG) has provided information to explore mineral resource opportunities and, more recently, insights to respond to geologic hazard challenges.

Communication is essential to successful information transfer. During 1988-89 the Division redoubled its efforts to reach its information users more effectively. This 81st Report of the State Geologist highlights some of these initiatives in selected areas.

• UNDERSTANDING EARTHQUAKE GROUND MOTIONS AND HOW THEY DAMAGE BUILDINGS

As a result of DMG's extensive monitoring activities, the October 1, 1987 Whittier Narrows Magnitude 5.9 earthquake generated more strong-motion records than any other event observed anywhere in the world. In order to encourage the use of these important data by the engineering community, DMG supported 11 investigations directed towards interpreting ground motion and building response records.

In May 1989, the Division held a workshop to review the results of the 11 investigations of the Whittier Narrows earthquake records with the scientific and engineering communities. Plans are underway to support additional investigations and to hold annual workshops to discuss their results.

• ACHIEVING MORE EARTHQUAKE RESISTANT HOSPITAL DESIGNS

The State has regulated earthquake resistant facility designs proposed for new hospital facilities since 1972. The Office of the State Architect contracts with the Division of Mines and Geology for evaluations of the engineering geology and ground motion analyses submitted by the applicants as part of the hospital foundation design plans presented to the State for review.

During 1988-89, DMG assisted the Office of the State Architect in revising the foundation design report requirements by contributing insights gained from over 15 years of reviewing these documents. The Office of the State Architect has also requested that DMG increase the number of design application reports which it reviews annually.

• THE FEASIBILITY OF AN EARTHQUAKE WARNING SYSTEM

It is technically possible to establish an Earthquake Warning System (EWS) which will detect strong ground motion generated by an earthquake while the fault rupturing is still in progress. The EWS can determine the size of the event taking place and the direction of fault rupture, and a warning message can be transmitted to appropriate areas up to 120 seconds before the damaging ground motion arrives.

During 1988-89, the Division of Mines and Geology explored the cost-effectiveness of an EWS in a section of California extending from Monterey Bay to the Mexican border. DMG concluded that the costs are not sufficiently offset by the savings to justify the installation of an EWS at the present time.

• MINED LAND RECLAMATION

In California, local governments have the responsibility for permitting and regulating mining activity. The Surface Mining and Reclamation Act of 1975 (SMARA) requires that mine operators submit reclamation plans for all lands disturbed since January 1, 1976 to appropriate local governments for approval. The Division of Mines and Geology has the responsibility to assist local governments in the review of plans submitted to them when they request it.

During 1988-89 DMG evaluated how to better advise mine operators regarding preparation of reclamation plans and how to better assist local governments in their analyses of them. After input from mine operators and local governments, DMG and the State Mining and Geology Board decided that the staff should prepare a reclamation planning and implementation guide. At the close of the fiscal year, this commitment to enhance DMG outreach was being implemented.

• MINING WASTE

Mine waste is generated as part of the extraction process in some mining operations within the state. Nationally, the Environmental Protection Agency (EPA) has the regulatory responsibility for mine waste. In 1986, the EPA decided to regulate mine wastes as nonhazardous substances, since the waste consists primarily of nontoxic local rock materials which have been moved only short distances from their original locations. The nonhazardous classification allows the EPA to include State governments in the regulatory process as is done in the administration of the treatment and disposal of municipal wastes.

In 1988, the EPA released draft regulations characterized as a "Strawman" to stimulate public commentary. The Western Governor's Association developed a task force of states to provide EPA with a coordinated commentary on "Strawman." The Division of Mines and Geology is playing an important role in the Mine Waste Task Force. The Mine Waste Task Force is probably providing more advice to EPA on environmental regulations, prior to their publication, than any other group has done in the past.

• CREATION OF AN ACTIVE MINES LIST

The enactment of Assembly Bill 747 in 1987 requires that mine operators have reclamation plans approved by local government by July 1, 1990, in order to continue mining in California. In mid-1988, the State Mining and Geology Board requested that the Division of Mines and Geology inventory the active mines in the state and determine the status of their use permits and reclamation plan approvals.

The DMG directed the entire staff of the Mineral Resource Appraisal Project (MRAP) to conduct the active mines inventory. The Division identified 1,012 active and intermittently active mines which were productive during 1988 and/or 1989. There were 319 mines in operation without approved reclamation plans. The Division of Mines and Geology has completed a milestone canvass which has demonstrated the need for greater communication among local governments, state and federal agencies and mineral producers in order to assure compliance with SMARA.

• PRUDENT POLICIES REGARDING CALIFORNIA'S MINERAL ENDOWMENT

In addition to providing information on mined land reclamation to local governments, SMARA also commits DMG to classifying areas according to their potential for future development of mineral deposits. The classification information provides land use regulators with the understanding of the trade-offs between preserving future mineral resource availability and land uses which are incompatible with surface mining.

Initially SMARA classification was restricted to identifying resources of sand, gravel and crushed rock aggregates for use locally in producing concrete in urbanizing areas where land-use competition was acute. The success of aggregate mineral resource classification in urbanizing areas led to the amendment of SMARA to have DMG evaluate the potential of non-aggregate types of mineral commodities in the non-urban areas throughout the state. In 1988-89 the State Mining and Geology Board requested DMG to integrate its methods of urban and non-urban classification activities in order to provide countywide reports. The new series is intended to increase the timeliness of the classification process and provision of information to users. The innovation will reduce DMG costs of report preparation. County governments will save because they will only have to modify their general plans once to accommodate the information in the single classification report dealing with their jurisdictions.

INTRODUCTION

California offers its citizens a unique combination of opportunities and challenges. The state is blessed with a magnificent coastline, majestic mountains, a fertile central valley and abundant mineral resources. These opportunities continue to attract a growing population. However, some challenges also come with these opportunities. Californians are challenged to assure safety of their lives and property in the face of active faults and volcanoes which characterize the dynamic conditions of California's portion of the Pacific rim. The fragility of the state's natural habitats and competition for space further challenge us to preserve the state's environmental quality.

During its 110-year history, the Division of Mines and Geology (DMG) has provided the geologic information needed to respond to these opportunities and challenges. Contributing critical insights to California's rapidly evolving public and private enterprises has required DMG to be on the cutting edge of the earth sciences throughout its existence. Some of the ways DMG responds to these opportunities and challenges are:

- Investigations - The Division prepares geologic maps and identifies where economically feasible mineral resource opportunities may exist. DMG also develops information to meet the challenges of active faults, damaging earthquake-generated ground motions, landslide-prone slopes and environmental protection.

- Outreach - In order to fulfill its role, DMG must not only carry out investigations, but it must also communicate the resulting information to those who need it. DMG reaches out to its users through its public information offices, through advisory services to other agencies, and through publications.

This 81st Annual Report of the State Geologist highlights some of the important initiatives undertaken by DMG during the 1988-89 fiscal year as the Division emphasized new ways to increase communication through outreach to its constituencies. The report is divided into two sections. Part I deals with new DMG efforts to increase seismic safety by improving the understanding of how buildings are damaged by groundshaking, advising on earthquake design requirements for new hospital construction and evaluating the feasibility of an Earthquake Warning System to alert metropolitan areas. Part II discusses DMG activities which relate to mineral policy. It summarizes new DMG directions in advisory services regarding mined land reclamation, regulation of mining waste, development of an active mines list and classification of mineral resources.

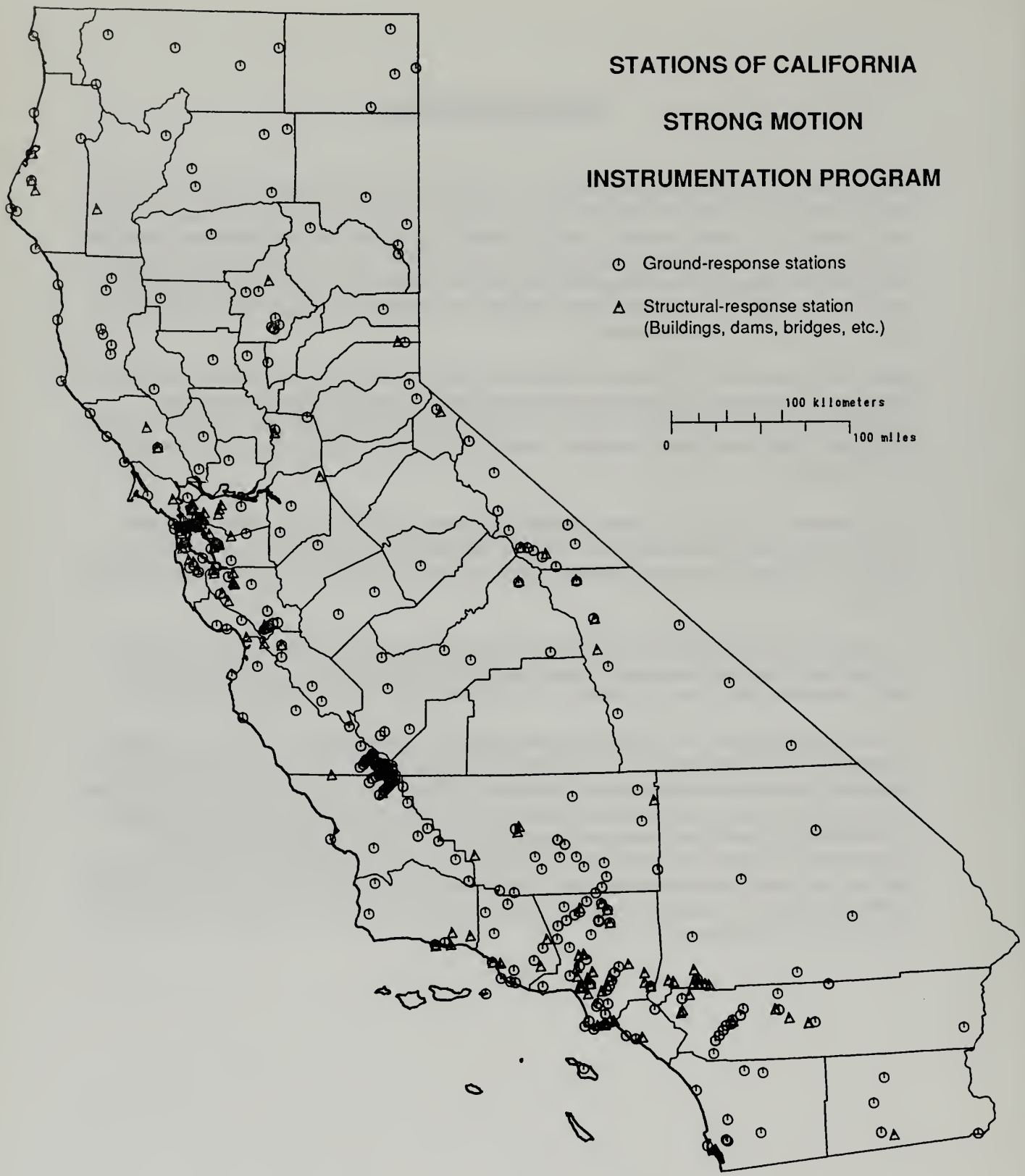


Figure 1. Map of the locations of the strong motion instruments in California at the end of Fiscal Year 1988-89.

PART I
SEISMIC SAFETY INITIATIVES

(6) DMG contributes to seismic safety through public information to citizens and scientific investigations to better define the earthquake hazards. A young citizen absorbs information about a seismograph at a DMG exhibit in the Los Angeles Convention Center during April, Earthquake Preparedness Month. *Photo by M. Flanery, DMG.*

(7) The DMG Strong Motion Instrumentation Program (SMIP) installs instruments like this one to record local ground motion associated with significant-sized earthquakes. The fiberglass hut protects the recording equipment inside. When the removable panels are in place, the equipment is completely protected. *Photo by SMIP staff.*

UNDERSTANDING EARTHQUAKE GROUND MOTIONS AND HOW THEY DAMAGE STRUCTURES

New Ground Motion Data

On October 1, 1987, the Magnitude (M_L) 5.9 Whittier Narrows earthquake occurred in Los Angeles County, causing over $300 million in damage. This event also generated the largest set of strong ground motion records of building responses ever obtained from a single earthquake anywhere in the world. Analysis of these records can help improve building codes and increase earthquake resistance of new construction.

The State Monitoring Program

This cornucopia of unique and valuable data recorded during the Whittier Narrows event was not an accidental windfall. The Division of Mines and Geology deploys equipment in seismically active areas of the state to monitor how the ground shakes and what actually happens when buildings experience earthquake shaking.

This Earthquake Engineering Program — also known as the Strong-Motion Instrumentation Program (SMIP) — was established within the Division of Mines and Geology after the occurrence of the M_L 6.4 1971 San Fernando earthquake. The San Fernando event caused unexpectedly severe damage to buildings which were constructed to the standards of the latest code, demonstrating the need for a better understanding of ground shaking and how structures fail.

The statewide network includes a total of 471 strong-motion instrument stations at the end of FY 1988-89 (Figure 1 on p. xii). Three hundred forty-two individual stations and two dense arrays of stations adjacent to faults have been established to record ground shaking in response to earthquakes. Additionally, 127 stations have been installed in buildings and in lifeline structures such as dams and transportation systems to record structural responses. In 1988-89, the rate of installation of stations was accelerated in order to achieve the goal of 775 high-priority stations by the year 2005. At that time there will be 435 ground response stations and 10 dense arrays, as well as 260 building installations and 70 lifeline stations.

(8) Understanding the effects of earthquakes on lifelines such as transportation facilities is important. The circle identifies a DMG strong-motion instrument station which was installed at the Bay Area Rapid Transit (BART) elevated structure near Hayward. Strong motions recorded at such stations during earthquakes are vital to understanding the performance of lifeline structures.

Outreach - A New Strategy for Data Utilization

Because of the extensive number of records derived from the Whittier Narrows event as well as records from several other earthquakes, the Division increased its efforts to encourage utilization of SMIP data during 1988-89. Previously, DMG efforts to facilitate utilization of SMIP data had emphasized timely (within 30 days) publication of strong-motion records recovered from significant earthquakes. In preparing these publications, the original records are digitized and processed using specially-developed computer programs and hardware. The resulting published strong-motion information includes ground accelerations, velocities, displacements and wavelength aspects of the processed records.

A new data utilization initiative is designed to share insights based upon research, using SMIP data, with engineers and building officials as quickly and as effectively as possible. The initiative consists of two elements: SMIP-sponsored analyses of the State strong-motion records by scientists and engineers in universities and private industry; and presentation of analytical results and conclusions at an annual seminar for earthquake scientists, practicing engineers and building officials.

Technology Transfer Seminar

More than 225 people participated in the first SMIP seminar held in Sacramento on May 19 and 20, 1989. SMIP had previously provided a total of $200,000 to support 11 studies of Whittier Narrows and other DMG strong-motion data. These funded research topics utilizing DMG strong-motion data were intended to answer specific questions regarding observed ground motions and structural responses.

New insights in four aspects of science and engineering which are important to future design of earthquake resistant structures in California were presented at the first seminar in May, 1989.

(9) The Imperial County Services building was built in 1978 to the Uniform Building Code requirements for earthquake resistance. DMG installed strong-motion instruments within and adjacent to the building prior to the October 1979 Imperial Valley earthquake. Notice the columns supporting the building at the first floor. *Photo by SMIP staff.*

These included:

- Geographic variations in the recorded ground motion intensities from the 1986 North Palm Springs and the 1987 Whittier Narrows earthquakes can be used to interpret the structure of the earth's crust in the Los Angeles region. This model will help forecast the patterns of ground motions which may be associated with future damaging earthquakes, and can be used in improved earthquake preparedness and building design requirements.

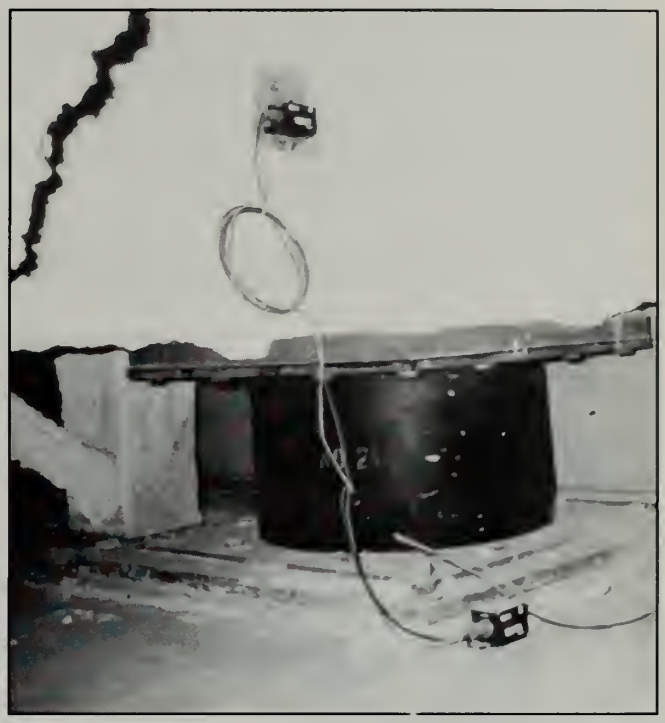
- The Whittier Narrows earthquake was produced by sudden displacement of rock on one side of an inclined fault, upward and over the adjoining section (thrust motion). In contrast, the largest Whittier Narrows aftershock resulted from horizontal displacement along a vertical fault. The differences in the ground motion recorded for these two events are interpreted to result from the two different types of displacement. This understanding will help forecast the character of ground motion that can be expected by similar types of movements along other faults.

- Several investigators assessed the ways in which different types of buildings responded to earthquake motion. The conclusions will be important in assessing how well the different types of structures will perform in future earthquakes.

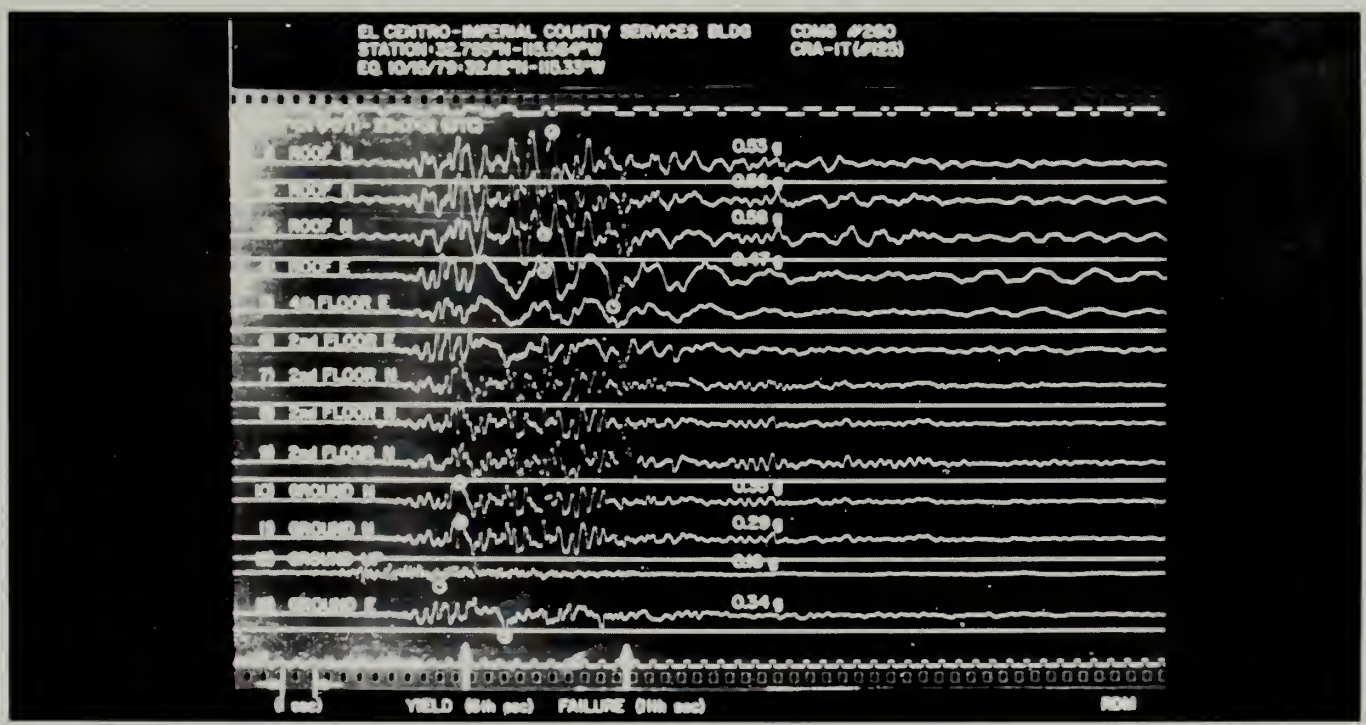
- The recorded responses of dams and freeway overpasses were compared to existing models that simulate the effects of earthquakes on these structures. Such comparisons may lead to better modeling for use in engineering designs.

It is hoped that the seminar will stimulate additional use of the SMIP database to increase seismic safety. Feedback to the Division of Mines and Geology has indicated that the participants felt the seminar and data utilization efforts of SMIP were very instructive to the engineering profession. Plans are going forward to support additional investigations and to hold similar seminars in the future.

(10) The 1979 Imperial Valley earthquake damaged the county building in several ways. Some of the vertical members which supported the building along its outside perimeter on the first floor were severely damaged. The performance of the building demonstrated the shortcomings of the contemporary building design requirements. *Photo by SMIP staff.*



(12) During the 1980's, a few new buildings were erected using base isolation design. The dark cylinder at the base of the structure is one of a set of base isolators which is intended to reduce the response of the building to ground shaking. Sensors at ground level and above the isolator (attached to the building) permit comparison of motions after a significant earthquake. *Photo by SMIP staff.*



(11) The response of the county building to the strong motion of the October 1979 Imperial Valley earthquake was recorded by SMIP instruments. Interpretation of these records allows identification of the times and locations of failures in the structure. *Photo by SMIP staff.*

(13) Olive View Hospital in Sylmar, California, was severely damaged during the San Fernando earthquake in 1971. The structure had been built according to contemporary earthquake resistant design requirements. The failure of Olive View Hospital prompted expanded State review of hospital design requirements. *Photo from DMG files.*

ACHIEVING MORE EARTHQUAKE RESISTANT HOSPITAL DESIGNS IN CALIFORNIA

Earthquake Resistant Design

California leads the nation and the world in the design and engineering of earthquake resistant structures. This is appropriate, given the earthquake challenge that exists in the nation's most populous state. The State's leadership also extends the application of these engineering insights to new construction. Like many other public policy enterprises, these efforts are achieved in California by a partnership of State and local governments. The State, through legislative action, prescribes the standards that must be applied by the local governments in their approvals of new construction permits. The Division of Mines and Geology provides important advisory services in this process.

Building codes have been used by local governments throughout California since the Long Beach earthquake of 1933. This effort has been actively improved by continuous upgrades of the codes to keep abreast of the advances in knowledge. The Division of Mines and Geology has an important role in acquiring new data which can be used in improving the Uniform Building Code. DMG also has an important seismic safety influence in the advisory services it provides through review of the ground motion design requirements proposed by applicants in plans for new hospital facilities in California.

State law requires special seismic design standards for public schools and hospital facilities. The school requirements were established by the Field Act, introduced by Assemblyman Dan Field in 1933, following the Long Beach earthquake which destroyed many public schools earlier in that year. The Office of the State Architect is responsible for reviewing plans prior to the beginning of a school's construction. The good performance of these structures, in many of the damaging earthquakes which have occurred since the Act was implemented, has demonstrated the effectiveness of this approach.

History of Hospital Design Requirements

The State has regulated the general design of new hospitals since the 1930's, but the need for stricter standards for seismic design was demonstrated by damage to the modern Olive View Hospital in Sylmar during the 1971

San Fernando earthquake. Damage to hospitals creates a double loss: the life and property losses attendant with collapse; and the inability to provide medical care to those individuals injured by the earthquake which damages the hospital. The Hospital Act of 1972, introduced in the legislature by Senator Alfred Alquist, is modeled after the Field Act and requires that plans for new hospitals and all major additions or alterations to existing hospitals be reviewed and approved by the Office of the State Architect. The State must also review seismological and geological reports on the site conditions of every proposed new hospital structure. The Division of Mines and Geology provides advisory services and reviews of hospital-site reports through contracts with the Office of the State Architect. The Office of the State Architect oversees the administration of this effort under Part 2 of Title 24 of the California Code of Regulations.

DMG Innovations in Design

In 1988, the Office of the State Architect announced its plan to revise the hospital design requirements of Title 24 as part of the revision of the Uniform Building Code. DMG was asked to suggest how seismic and geologic site analyses could be improved. Motivation came from the need for clarifying existing Title 24 language, from greater safety mandated in new codes, from the experience gained by DMG in reviewing reports submitted since 1973, and from the development of new concepts of design and site evaluation.

In its newest version, Title 24 requires evaluation of: the geologic character of the site and environs; known and potentially active faults which can affect the site; estimation of the ground motion associated with the "maximum probable" and "maximum credible" seismic events; slope failure (landsliding) potential; and the susceptibility of soils to loss of strength during shaking (ground failure).

The design requirements of Title 24 are linked to the concepts of "maximum probable" and "maximum credible" earthquakes. The shaking that is anticipated to be associated with the "maximum probable" earthquake is estimated to be the greatest ground motion that the candidate hospital site will experience during the next 100 years. Buildings which are designed for the "maximum probable" event should be able to still function as hospitals after the earthquake. The shaking associated with the "maximum credible" earthquake is the most severe ground motion that is ever considered to be possible at the site in the future. Hospitals built to withstand this greater shaking requirement will not be expected to collapse, but may not be able to function as care facilities following the event.

The revised Title 24 requires that applicants provide sufficient data and documentation in their reports so that their conclusions regarding the severity of the design ground motion can be rigorously reviewed. Title 24 revisions also specify that the engineering geology conclusions regarding soil conditions and design ground motion be reviewed by the State before the hospital design is completed by the applicant. This affords the opportunity for State input before the report is completed and creates a more efficient review process.

Expanded DMG Advisory Service

During 1988-89, the Division entered into an expanded review contract with the Office of the State Architect. This expansion resulted from an increase in the number of hospital design applications being submitted and from the desire of the State Architect to have all proposed hospital site reports reviewed by DMG. The number of reviews conducted by DMG rose from about 50 in Fiscal Year 1984-85 to over 160 in 1988-89. The reviews are very labor-intensive; site visits are often needed to completely evaluate many of the proposals.

To meet this need, the Office of the State Architect increased funding to DMG in 1989-90 to provide for additional staffing of the DMG review activities. These developments demonstrate the Division's commitment to continue its outreach to the engineering and local government constituencies.

FEASIBILITY OF AN EARTHQUAKE WARNING SYSTEM IN CALIFORNIA

An Emerging Technology

As new capabilities to deal with geologic hazards emerge, the Division of Mines and Geology explores their application to protection of life and property in California as part of its advisory service responsibilities. In 1985 several scientific articles appeared describing a new technical capability of detecting a large earthquake just after rupturing along the source fault had begun, and of transmitting a warning of the approach of damaging strong ground motion to distant communities. This warning could arrive a number of seconds before the groundshaking. The technology employs microwave and radio signals travelling at the speed of light, which is much faster than earthquake shock waves. This warning transmission technique is already being employed in Japan to stop the high speed bullet trains before they run over damaged tracks.

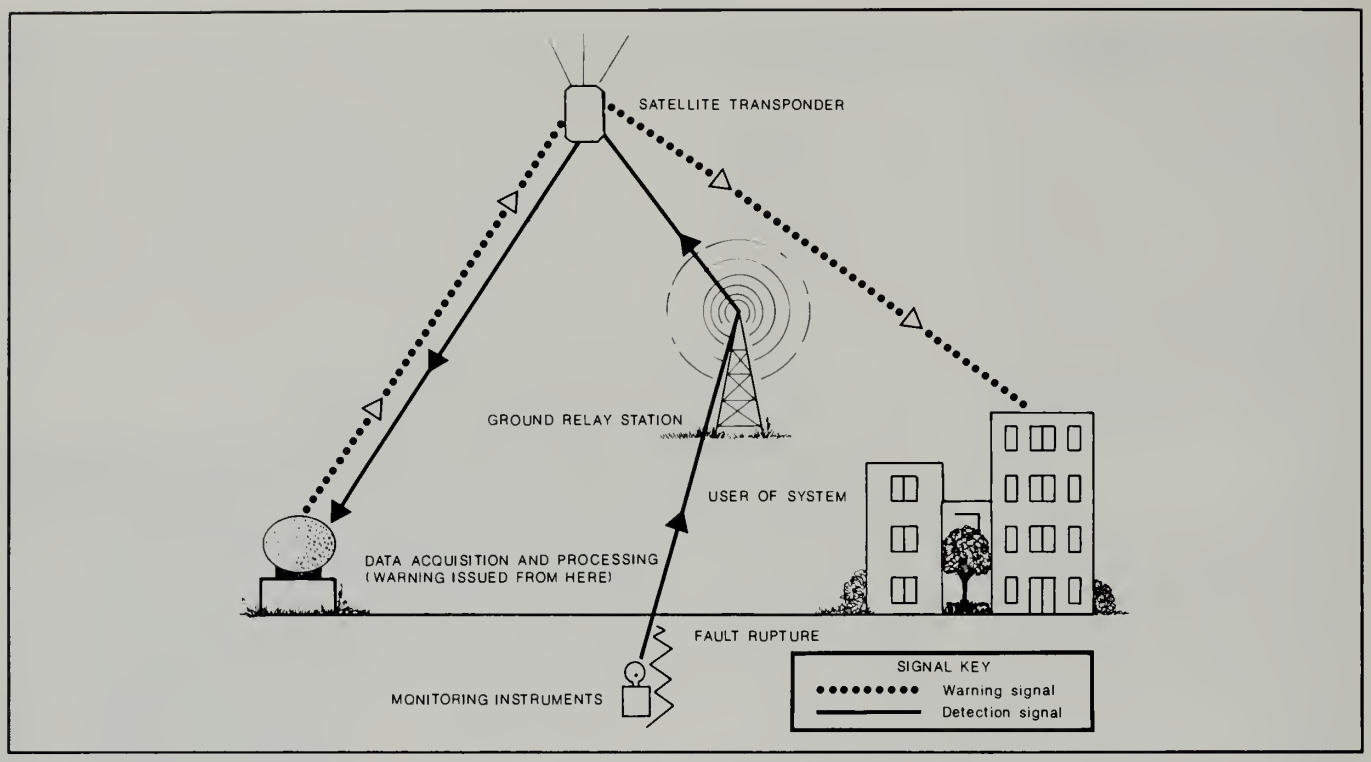


Figure 2. Existing technology affords the opportunity to install Earthquake Warning Systems (EWS) using the components illustrated here. It is possible to detect earthquake ground motion while movement along the fault is still in progress. This detected signal can be transmitted via satellite to a ground-based data processor. If it is determined that damaging ground motion is moving towards a metropolitan area, a warning can be transmitted via the satellite which would reach recipients of the message a number of seconds before the earthquake waves arrive.

The Earthquake Warning System, or EWS, that might be established is quite different from an earthquake prediction. A successful short-term earthquake prediction would provide hours to weeks of lead time before the anticipated damaging event takes place. An EWS, however, provides only a few seconds of warning of an earthquake already in progress. Further research is needed to determine whether or not short-term earthquake predictions will be scientifically possible in the future. Although the EWS is technically feasible, it is necessary to evaluate its economic feasibility and cost-effectiveness before this new advance can be employed in California.

EWS Technical Basis

The EWS can be based upon determining the location, size and direction of rupture during the earthquake. This capability depends upon telemetry communications between recording instruments systematically arranged along specific faults, a computer which can analyze the incoming signals from the recorders in near-real time and a microwave or radio relay system to send warning messages on appropriate occasions.

Earthquake waves are of two types: the relatively fast P-waves which rarely cause damage and arrive at the earth's surface first; and the slower S-waves which are principally responsible for the damaging strong ground motion and arrive later at locations along the wave path. The length of time between the beginning of fault rupture and the P-wave arrival at the earth's surface directly above the origin (epicenter) would be about 1.6 seconds if the rupturing begins at a depth of about 6 to 7 miles, which is a common depth of events in California. Approximately 5 seconds later, the S-waves would trigger two earthquake warning monitors along the fault. One second later, it would be technically possible to complete an instantaneous computer analysis which would determine if the event were large enough to be damaging and to interpret the direction along the fault in which the rupturing was taking place. This circumstance could permit a message to be transmitted instantly to receiver stations in the region which could, depending on circumstances, give as much as 120 seconds of warning in an area which would be significantly damaged. A diagram of the elements in such an EWS is shown in Figure 2. The amount of lead time would depend upon the configuration of the seismometer

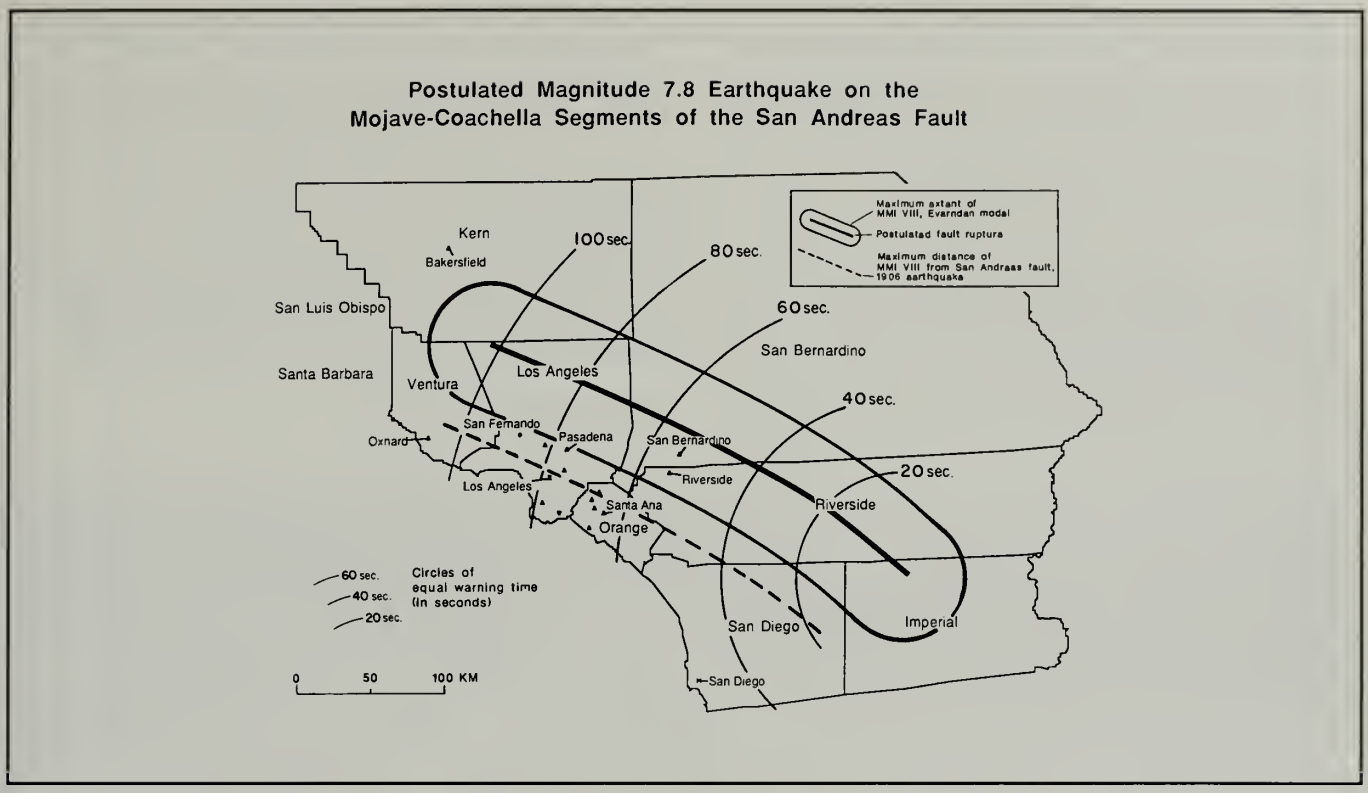


Figure 3. If an earthquake began by rupturing along the San Andreas fault in Imperial County, it would take 70 to 100 seconds for the damaging ground motion to arrive in the Los Angeles area. An Earthquake Warning System could give a warning with a lead time of 70 to 100 seconds to recipients in the Los Angeles region. The approximate area of greatest ground shaking (Intensity VIII on the Modified Mercalli Intensity Scale) is shown within the elliptical region surrounding the segment of the San Andreas fault along which the postulated rupture is taking place.

network, and the extent and pattern of the rupture along the fault which generates the strong ground motion. A hypothetical example is shown in Figure 3. In this example which could afford portions of Los Angeles County up to 100 seconds of lead time, the fault rupture is assumed to begin at the southeast portion of the San Andreas fault in Imperial County. Conversely, if the rupture were to begin in northern Los Angeles County, the residents of that county would get very little lead time and portions of Imperial County would benefit from the 100 seconds of warning.

Applications of the Techology

In an effort to find out the practical applications of EWS capability, the legislature enacted a bill in 1987 which authorized DMG to evaluate the effectiveness of an EWS to detect activity on the San Andreas fault south of Monterey County. The study area covered a 73,500 square mile region where two-thirds of the state's population reside. DMG investigators identified four types of uses of the warning:

- personal safety of citizens inside or outside of structures;
- computer shutdown to avoid hardware damage and data loss;
- facility shutdown applications which would switch off manufacturing equipment and fabrication processes that could be more extensively damaged by strong ground shaking when in operation; and
- preventative safety measures such as diverting approaching aircraft at airports, securing large animals in zoos, etc.

DMG surveyed 164 potential users who identified 82 discrete types of uses of lead times between 1 and 120 seconds in the four major categories mentioned above. The survey garnered responses from large and small corporations, public officials, lifeline managers, educators, bankers, and computer system managers. Potential users indicated a desire for at least 30 seconds of warning before the arrival of damaging ground motion. There appear to be few uses for fewer than 30 seconds of warning. Many uses

would require 60 to 120 seconds of warning time. In southern California, the longer lead times required by users make the EWS practical only for the lengthy San Andreas fault. Furthermore, the location on the fault where the first rupture occurred in relation to population centers would influence the actual lead time available to those communities which would receive the warning.

The survey also indicated significant concern over the possibility of false alarms. The design of the system must consider avoidance of false alarms due to system failure and due to the possibility of monitored ground motion induced by earthquakes generated on other faults in the area being misinterpreted by the EWS to be events occurring on the San Andreas.

Cost-Effectiveness

The cost-effectiveness analysis indicated that because sufficiently large benefits cannot be presently assured, it does not appear justifiable to construct an EWS in southern California at this time.

The benefits were appraised employing the responses of the potential users who were surveyed. The estimated savings and false alarm costs were too variable to be used in a rigorous cost-benefit analysis. The DMG study does indicate, however, that the savings achieved by users employing the EWS would have to be tens to hundreds of millions of dollars in order to make the system cost-effective. These savings should be substantially greater (10 to 50 times) than the cost of responding to false alarms. The study concludes that it is not certain that these standards can be met.

DMG Advisory Conclusions

This important investigation, summarized in DMG Special Report 161 published in 1989, provides useful policy guidance on the present feasibility of using an EWS in the state. Important contacts with the potential users can be maintained and these can permit further dialogue on the cost-effectiveness of this method or other techniques when future circumstances make this desirable.

PART II
MINERAL POLICY INITIATIVES

(14) The open pit mine at Boron, California, is the world's principal source of borates. To expose the ore, which lies 300 to 600 feet below the surface, the overburden is removed using explosives, electric shovels and giant trucks. Shown here is a shovel which scoops up 30 tons of earth in a single bite and loads it into a truck which can carry up to 150 tons. *Photo courtesy of U.S. Borax and Chemical Company.*

(15) Unreclaimed mines, such as this sand and gravel pit which produced aggregate, have no planned socially beneficial subsequent use. This abandoned mine has no restrictions to access and has become an unsightly illegal dump.

NEW LAND USES FOR OLD — MINED LAND RECLAMATION

The DMG Advisory Role

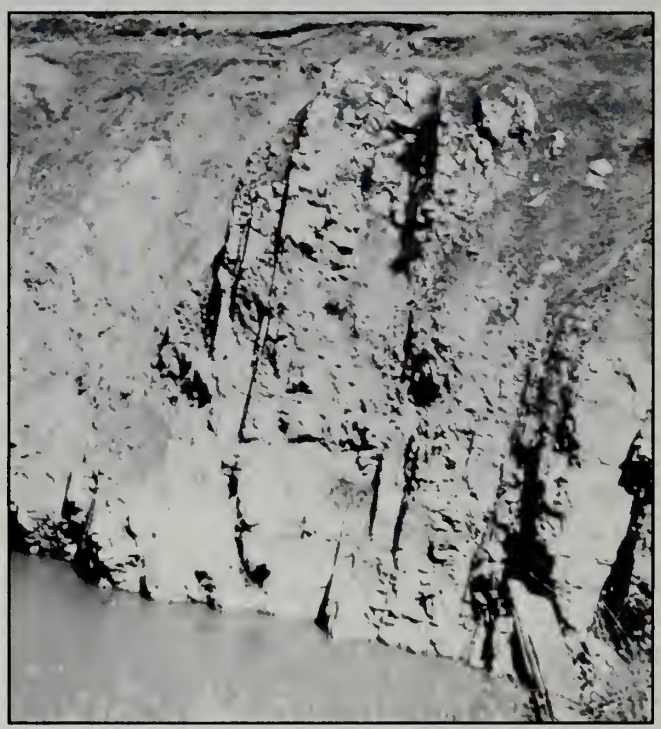
The Surface Mining and Reclamation Act (SMARA) establishes a requirement that lands mined after January 1, 1976 are to be reclaimed to safe, environmentally satisfactory post-mining uses.

The Act provides that the land use permitting system for mine operation continues to be under the jurisdiction of local governments. Local governments, known in the Act as "lead agencies," are required to develop reclamation ordinances and have the authority and responsibility for approval of the reclamation plans prior to mining. Currently not all mine operators are complying with the reclamation requirements of SMARA. These circumstances have prompted DMG to carry out an inventory of active mines and status of their reclamation plans. The statistics of this survey are summarized in the section of this report entitled "Creating an Active Mine List."

Failure to properly reclaim mined lands not only creates a negative public perception of mining but can result in serious threats to the environment and public health and safety. According to a recently published mining waste study conducted by U.C. Berkeley, one of the most persistent and adverse impacts that can result from improper closure of a mine is acid mine drainage. Where metal sulfide deposits are in contact with water in unreclaimed mines, acid mine drainage will result. Contaminants from such mines can eliminate aquatic life in the creeks below the mine and threaten unpolluted water supplies. Consequently, effective implementation of SMARA reclamation requirements is essential to avoid adverse effects through proper closure of mines.

Through careful planning, mined land can be restored to a variety of productive end uses. Examples of beneficial end uses for mined land in California include agriculture, residential and industrial developments, landfills, golf courses, botanical gardens, wildlife habitats, and percolation basins for ground water recharge.

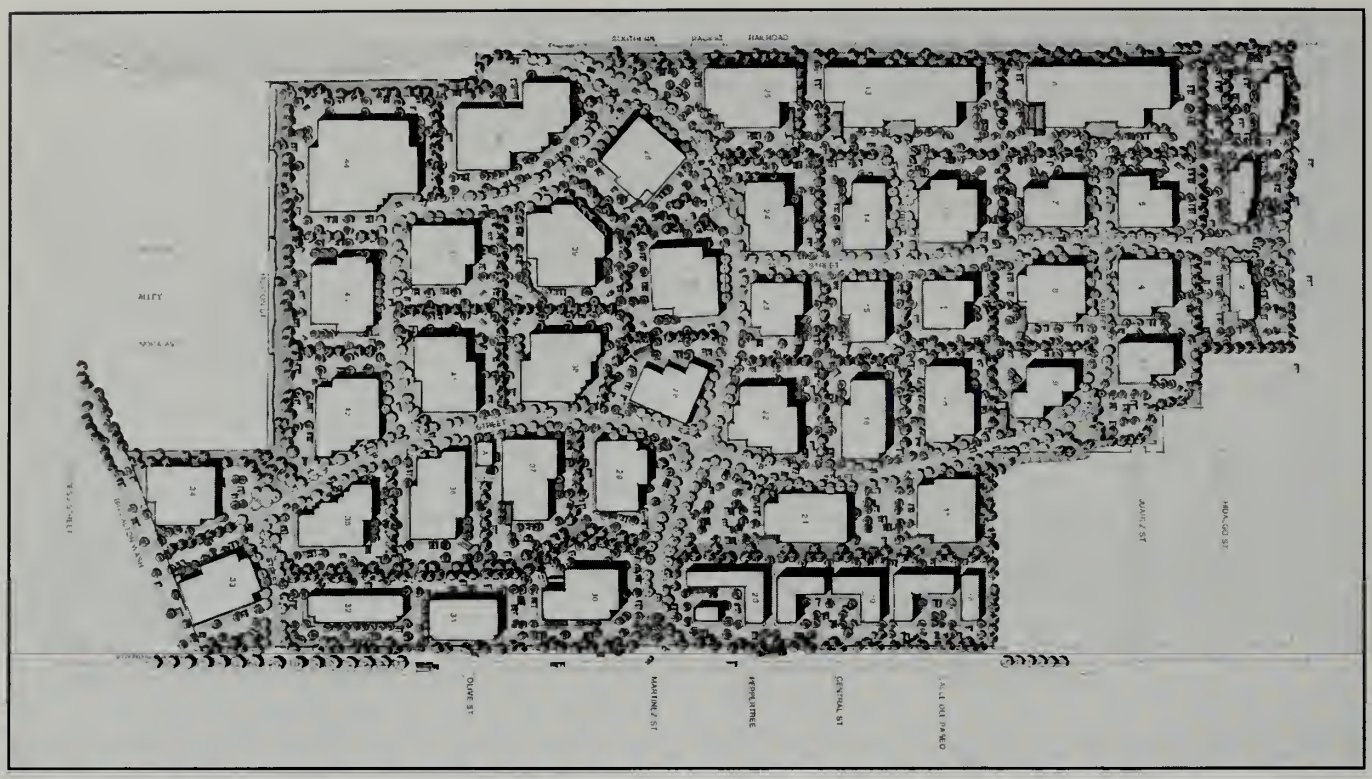
The Division of Mines and Geology has the responsibility, if requested by a lead agency, to furnish technical assistance in reviewing the reclamation plans submitted by mining companies. The State Mining and Geology Board reviews lead agency ordinances for compliance with SMARA, provides policy oversight for the Division's reclamation activities, and may also serve as



(16) Some unreclaimed abandoned mines are safety hazards. This mine has sheer rock walls approximately 80 feet high. A deep pool of water occupies the lower portion of the excavation, which not only compounds the safety problem, but diverts surface water drainage.

(17) During mining, before reclamation: An aerial view of a large sand and gravel operation belonging to CALMAT Corporation in the Irwindale area. The property is located in the center of the San Gabriel Valley within Los Angeles County. It provided a great deal of concrete aggregate for construction in the metropolitan region. This photo was taken during the mid-1960's when extraction was still in progress. The mine was approximately 150 feet deep. *Photo courtesy of CALMAT Corporation.*

(18) During reclamation: An aerial view of the same CALMAT mine as it appeared in 1989 shows the pit being filled in as part of the reclamation process. The excavation is being graded to within 35 feet of the elevation of the perimeter by deposition of commercially unusable fill materials such as silt. Some sand and gravel are also being added from a nearby excavation. *Photo courtesy of CALMAT Corporation.*



(19) After reclamation: An artist's rendition of the CALMAT Corporation Irwindale Industry Center at the time of its anticipated completion in 1997. The facility will extend over 120 acres and will be occupied by over 40 sizeable buildings totalling 1.7 million square feet. There will be parking for 4,500 cars. *Illustration courtesy of CALMAT Corporation.*

the lead agency in the reclamation plan review and approval process if a local government does not fulfill its SMARA responsibilities.

In addition to complying with SMARA, mine operators must conform to the requirements of the California Environmental Quality Act, other State environmental regulations and the National Environmental Protection Act.

Under the guidance of the State Mining and Geology Board and the Department of Conservation, the Division has sought ways in which it can efficiently and effectively provide technical assistance on reclamation to local governments. The advisory services may include:

- commenting on proposed reclamation plans as requested by local governments;
- conducting information workshops for lead agency and industry participants;
- making site visits to selected properties before and after mining begins; and
- preparing publications for use by lead agencies and industry.

To fill these needs the DMG reclamation staff includes individuals with backgrounds in mining engineering, engineering geology, erosion control, hydrology, and plant ecology. In its effort to improve the effectiveness of the reclamation element of SMARA, DMG is identifying active mines without approved plans and intensifying its efforts to provide technical advice through the development of the procedures guide.

A New Approach to Technical Advice

In the tradition of actively providing information to the public, the Division has produced a number of publications, including most recently two special publications on hydrology and in-stream mining. During 1988-89 the staff began preparing a publication that would provide general advice to lead agencies and to mining companies on the preparation of reclamation plans. In association with the State Mining and Geology Board, DMG staff explored a number of different formats to achieve statewide consistency and improve the quality of reclamation plans. These included development of a model reclamation plan, a check list for reclamation plans and a reclamation planning and implementation guide.

Provision of general information regarding desirable reclamation practices and policies is a challenge in California because mining is taking place in all of the climatic regions spanning from desert to mountainous coastal areas with very high levels of rainfall. Plant life, topography, water and drainage patterns and engineering conditions vary greatly in these environments. Thus, a simple, straightforward prescriptive approach is not as practical as it would be in states with less environmental diversity.

Opportunities for public commentaries on the several formats that DMG was considering for the advisory publication were provided at State Mining and Geology Board meetings during 1988-89. Subsequently, it was decided that the Division would prepare a reclamation planning and implementation guide. Its purpose will be to advise the mine applicants and local government reviewers on how to appropriately describe the location and topography, geologic setting and the characteristics of the proposed sites in terms that are relevant to reclamation planning.

Information will also be provided on topsoil management and erosion control methods, land-shaping techniques and revegetation practices. Special reclamation situations such as in-stream mining, percolation ponds, and wildlife issues will also be addressed. During the 1989-90 fiscal year, the reclamation staff will complete the reclamation planning and implementation guide using input from the State Mining and Geology Board and other informed sources.

(21) The Larkspur Landing residential development occupies a scenic location at the base of a former rock quarry in Marin County. Crushed rock aggregate was produced from the quarried rock. *Photo by K. A. Cole.*

(20) A golf course has been developed on mined land reclaimed by the Chandler Sand and Gravel Company in a portion of the mine formerly occupied by silt ponds. The pit in the background is also being reclaimed. The mine is located on the Palos Verdes peninsula. *Photo courtesy of Southern California Rock Products Association.*

(22) Anaheim Lake in Orange County is a former mine that is owned by the County Water District. The District stores water from the Colorado River in this and in similar excavations, allowing the water to infiltrate into underground aquifers from which it can be withdrawn. *Photo courtesy of Southern California Rock Products Association.*

MINING WASTE — DEVELOPMENT OF COMPATIBLE STATE AND FEDERAL REGULATIONS FOR ASSURING ENVIRONMENTAL QUALITY IN CALIFORNIA

Production of Mine Waste

The State of California is the nation's largest producer of non-fuel mineral commodities. California's annual production (1988) is valued at close to $3 billion, about 10 percent of the nation's output. Mining in California provides the raw materials used in diverse and essential activities such as construction, agriculture, medicine, forestry, manufacturing, and electronic technologies. Mining of some commodities results in production of large quantities of waste material by-products which must be dealt with in an environmentally sound manner. Mining waste is the unused rock material that results from the extraction or processing of mineral products for commercial purposes. Some examples include: in concrete, the material washed from sand and gravel before being mixed with cement; in selective mining, the material set aside that does not meet specifications; and in metal mining, the fine-grained tailings removed from the metallic minerals as they are separated by grinding and milling. If the deposit is below soil or other overburden, this overlying material must be stripped off and set aside before mining can take place. Soil can be reapplied when the land is reclaimed, but other materials are mining waste.

Nationally, mine wastes amount to between one and two billion tons of rock and mine tailings annually. California contributes substantially to this total.

Regulation of Mine Waste

Although the disposition of California mine wastes from current operations must be addressed under the provisions of the Surface Mining and Reclamation Act of 1975, other regulations directed specifically at water and air quality also apply.

In California, the State Water Resources Control Board and the Regional Water Quality Control Boards are responsible for ensuring that the disposal of these wastes does not adversely impact water quality. At the national level, the Environmental Protection Agency (EPA) has jurisdiction over regulation of mine wastes under the Resource Conservation and Recovery Act (RCRA) of

(23) Heap leach pads at the Cactus Mine in south-central Kern County in the Mojave Desert, about 60 miles north of Los Angeles. The mine is situated to the east (right) beyond the photo. Following mining, rock heaps will be rinsed, neutralized and contoured, then revegetated. *Photo by J. Burnett, DMG Staff.*

1976. Wastes from mining and processing operations are not currently regulated under RCRA by the federal government, but a concerted effort to finalize RCRA regulations is in progress.

In 1985, EPA issued a report on wastes associated with mining phosphate rock, oil shale and asbestos as well as overburden stripped off of uranium ores and the discharges from the extraction and concentration of metallic ores. In 1986, EPA decided not to regulate mine wastes under RCRA, Subtitle C, as hazardous wastes, because the materials are usually naturally occurring derivatives of local rock that have been moved from their original locality to nearby sites during the mining process. EPA decided to expand the scope of Subtitle D of RCRA, which applies to nonhazardous solid wastes generated by municipal and industrial activities. This change is critical because, unlike the hazardous waste covered in Subtitle C, the statute for solid wastes of Subtitle D permits EPA to develop an effective state-federal program for regulating mining waste in the same fashion it does for management of other non-hazardous wastes generated by municipalities and industrial entities. Such an arrangement would provide states the opportunity to regulate mining wastes within their jurisdictions in order to achieve national environmental standards set forth by EPA. This is the approach used in the federal regulation of the surface mining of coal under the Surface Mining and Reclamation Act of 1976, administered by the Office of Surface Mining in the U.S. Department of the Interior.

DMG Role in State Advice to EPA

In April of 1988, EPA announced it was developing a preliminary regulatory outline for mining wastes to be informally known as "Strawman," referring to its release as a tentative document for public comment. EPA stated that "Strawman" was not a proposed rule, but rather a first effort at presenting what a regulatory approach could be. The proposed "Strawman" outline of the draft regulations has two major elements.

"Strawman" Part I provides that each state must present a Mining Waste Management Plan that identifies an agency with primary responsibility within the state and defines the roles of all agencies responsible for water, air and other environmental aspects. It also provides for a 10-year permit granting process for mine operators. Mine wastes,

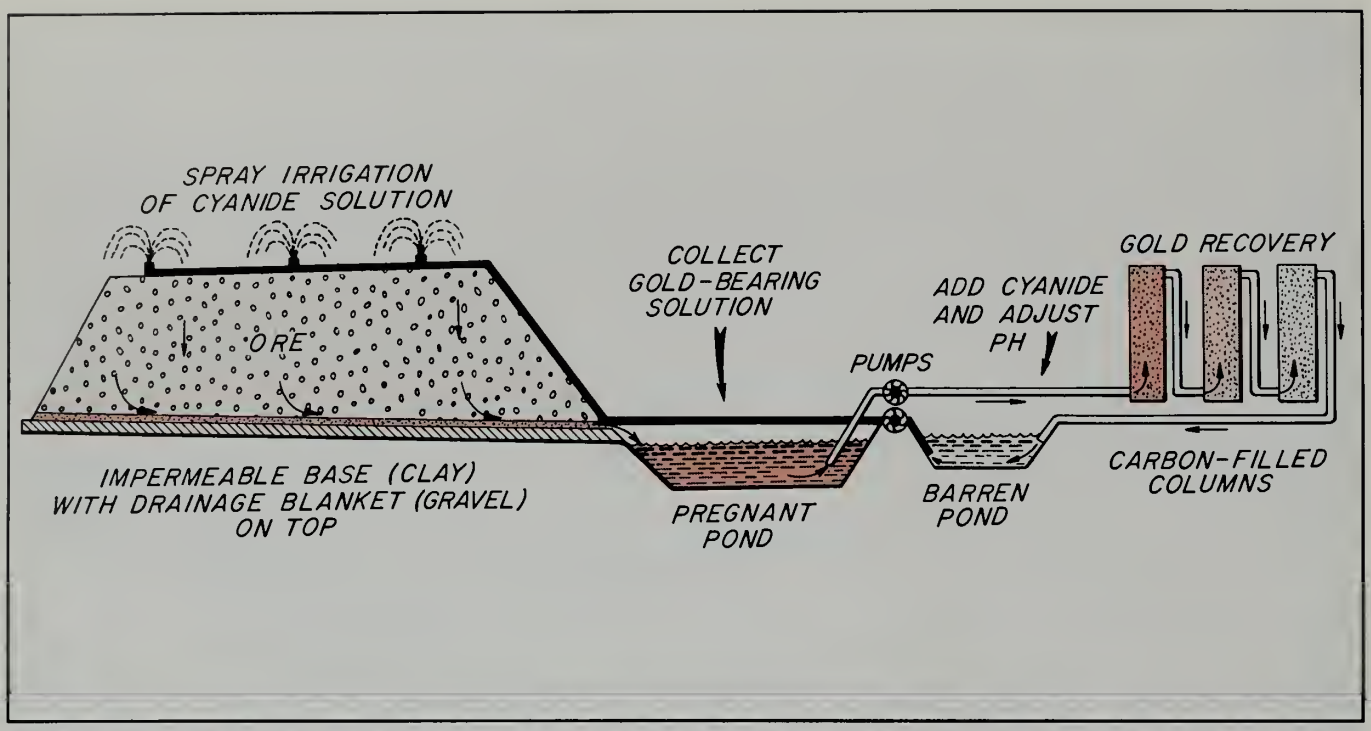


Figure 4. Modern gold mining in California is making extensive use of the heap leaching process illustrated above in a generalized diagram (after Cole, California Geology, 1983). Crushed gold ore is heaped into pads through which cyanide solution is percolated. The gold is dissolved by the cyanide solution collected in the pond and pumped to the recovery plant where it is separated. The spent solution is sent to a second pond where it is amended and reused. Mine waste resulting from heap leaching can include tailings, waste rock removed in the excavating process, as well as spent heap leach pads.

in any states not certified by EPA to conduct the program, will be regulated by the EPA regional office in their area.

Part II contains the technical criteria for performances. The standards would apply only to the waste of existing (i.e., not abandoned) facilities and mines. Included are: overburden stripped from uranium deposits; waste products from asbestos, phosphatic rock, and oil shale operations; and waste products from milling metallic ores. In addition, heap leach operations to extract gold would be subject to the criteria at time of mine closure (see Figure 4). The states are to establish performance goals for protection of ground and surface waters and may establish goals for air quality. To meet these mine waste performance criteria, attention must be given to the specific operation location, with respect to flood plains, wetlands, seismic impact zones, complex hydrology, etc. To function in this effort, the states must establish procedures for taking corrective actions when necessary.

Concerns over the unilateral development of national standards that would later have to be implemented by the states prompted the Western Governor's Association (WGA) to coordinate state involvement in the development of these federal regulations through a task force providing information on:

- existing state laws and regulations applying to mine wastes;
- current status of mining waste management practices within the states;
- feedback to EPA on its draft "Strawman" mine waste regulations; and
- a white paper describing the states' position on regulation of mining wastes.

The task force was established in April of 1988. Participating states include Arizona, California, Colorado, Florida, Idaho, Minnesota, Missouri, Montana, Nevada, New Mexico, Wisconsin, and Wyoming.

The lead California participation in the task force is through the Vice Chairperson of the State Water Resources Control Board. The Senior Mining Engineer of the Division of Mines and Geology mined land reclamation project is the alternate California representative.

The DMG is playing an important role in this vital advisory process to EPA on behalf of California. In addition to serving as the lead representative for California at

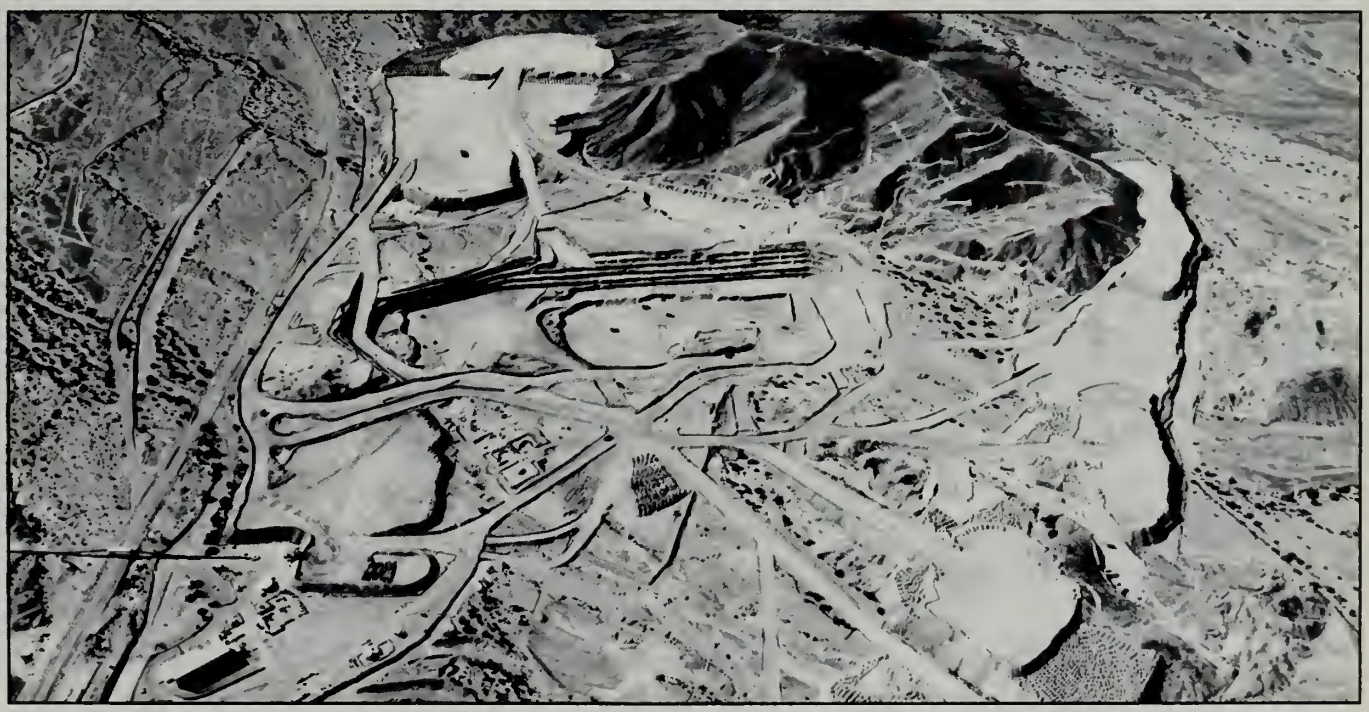
many of the task force meetings, the Division has facilitated collation of information on production of mine wastes within the state, inventoried existing regulations and their costs, and coordinated state comments on the draft "Strawman" regulations. DMG has also made important suggestions. For instance, in concert with the State Water Resources Control Board, in the area of cyanide heap leaching for gold, the Division recommended that the mine waste regulations apply at the time of construction of the leaching pad rather than at the conclusion of mining as the draft EPA regulations proposed. This should assure the original design of the pad will be adequate to minimize adverse environmental impacts.

As Fiscal Year 1988-89 came to a close, the WGA task force was developing its feedback to EPA on the "Strawman" regulations. DMG information was being merged with material of other states regarding:

- the quantities and characteristics of mining wastes being produced;
- an inventory of existing state statutory and regulatory programs and advice on their influences on interaction with federal activities;
- legal reviews of the existing state and federal regulations and how they relate to the proposed EPA regulations;
- identification of gaps in the proposed regulations and in existing state activities; and
- comparison of the cost of existing state programs and their impacts, with estimates of the costs of implementing the proposed federal program and its effectiveness.

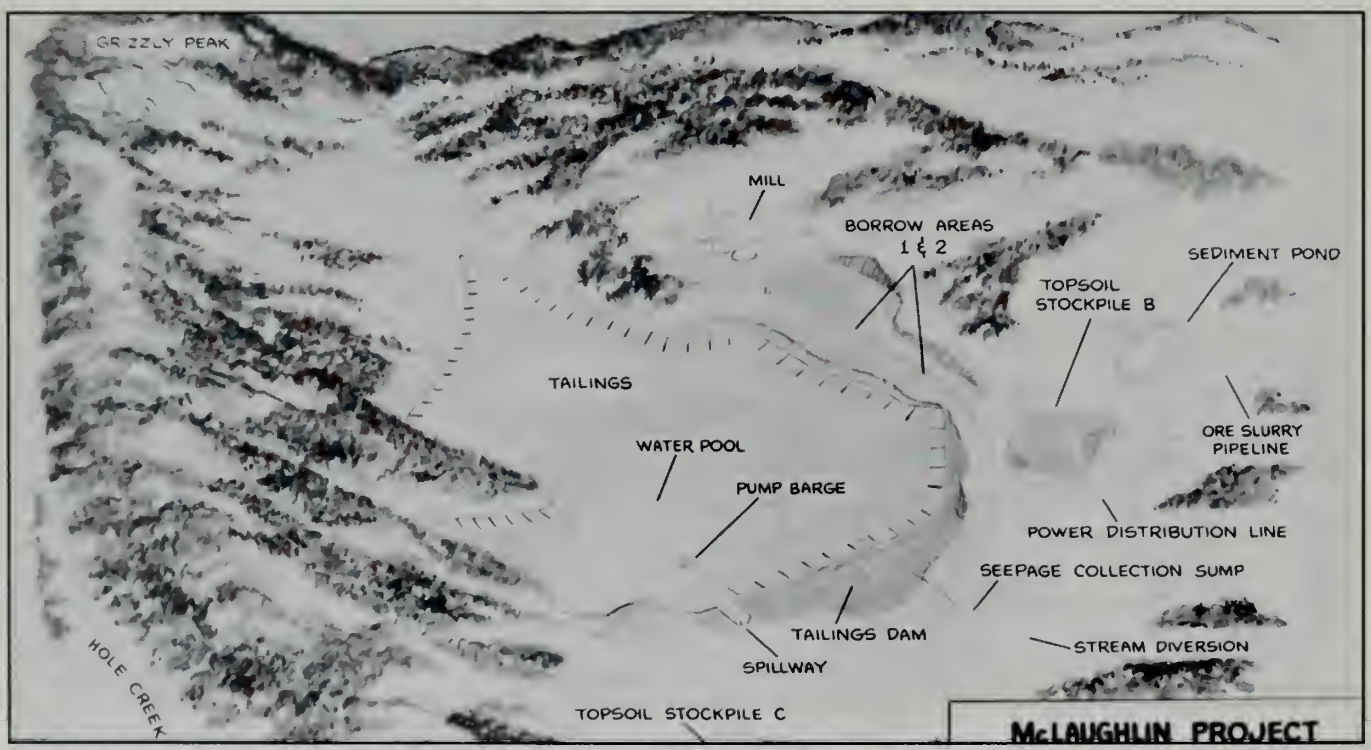
The task force was also drafting a white paper as a companion to its edited version of the"Strawman" regulation outline. The task force has advocated state primacy in the administration of regulating mining waste management and has considered ways of dealing with abandoned mines and types of active mine operations which are not currently within the scope of the proposed EPA regulations or the EPA Superfund program.

These efforts represent an unprecedented approach in which states have communicated in a coordinated manner with a federal agency such as EPA, prior to a national regulatory program being adopted. DMG has been an important part of these advisory services and outreach processes.



(24) Oblique aerial view of the Mesquite Mine at the western Chocolate Mountains in eastern Imperial County. The Big Chief pit where the ore is excavated is located centrally. Waste rock is piled laterally in the dimpled areas radially away from the pit. Tailings deposits make up the flat areas adjacent to the waste rock. The heap leach pads are outside of the picture to the east (left, out of view). *Photo courtesy of Gold Fields Mining Company.*

(25) Mining activity takes place in some highly urbanized settings, such as these sand and gravel excavation locations. Irwindale is in the foreground. The Santa Fe Dam and Flood Control Basin are in the upper right hand portion of the photograph. *Photo courtesy of Southern California Rock Products Association.*



(26) This illustration presents the planned post-mining reclamation of the tailings deposits at the McLaughlin Gold Mine. The mine is located at the junction of Napa, Lake and Yolo counties. Plans call for top soil to be returned to the area prior to reseeding and use for livestock grazing. *Illustration courtesy of Homestake Gold Mining Corporation.*

CREATING AN ACTIVE MINES LIST — COMMUNICATIONS NETWORKING BETWEEN FEDERAL, STATE, AND LOCAL GOVERNMENTS AND THE MINING INDUSTRY

The Need for a Comprehensive Active Mines List

California's leadership in non-fuel mineral production, which amounts to close to $3 billion annually, is sustained by the output of over 1,000 currently active mines. Approximately 67 percent of these operations are producers of construction aggregates (sand, gravel and crushed stone). About 25 percent are industrial mineral producers (limestone for cement, borates, diatomite, clays, rare earths and saline minerals, etc.) and about eight percent are metal mines (gold, tungsten and silver).

As pointed out in the previous section about the regulation of California mining wastes, the mining activity of California is vital to supplying our societal needs, but it is also essential that this extraction be done in an environmentally sound manner. The Surface Mining and Reclamation Act of 1975 became effective January 1, 1976. The Act requires that land disturbed after that date be reclaimed under local government (lead agency) ordinances in compliance with state standards. As SMARA was originally enacted, new permits were not required of mine operators with vested rights (those in operation prior to the law becoming effective). However, parties with vested rights were required to submit their reclamation plans to lead agencies for lands mined after the law went into effect. Once submitted, they were to receive approval of these plans "within a reasonable period of time" from the lead agency.

In order to clarify compliance requirements, Assembly Bill 747 was passed in 1987 amending SMARA. This provision requires that operators of mines with vested rights in 1976, but without approved reclamation plans, submit plans to the appropriate lead agency by March 31, 1988. The amended act also provides that those operations without approved plans by July 1, 1990 would be prohibited from further surface mining until approved plans were secured, unless special circumstances prescribed in the statute existed.

In order to assess the degree of compliance with the amended SMARA reclamation provision, the State Mining and Geology Board, in July 1988, requested that within one year the Division of Mines and Geology complete a comprehensive inventory of active mining operations subject to SMARA within California, including information on the status of submission and approval of their reclamation plans.

(27) Mining also takes place in agricultural areas. This mine was operated along Santiago Creek in Orange County. The mine no longer exists. Portions of the mine have been reclaimed for a mobile home park and other portions are used for water storage. *Photo courtesy of Southern California Rock Products Association.*

DMG Response to the Need

The Division responded to the request by expanding its computer database to collect additional information on mining operations subject to SMARA as part of its inventory of active mines.

The task was assigned to the Mineral Resource Appraisal Project (MRAP). MRAP has traditionally maintained DMG files on mineral property reports, mineral production statistics and more recently has developed a computer database on mining activity. MRAP expanded the database to contain information on approval dates for land use permits and reclamation plans. Conditional use requirements and other data relevant to the status of mining activities were also added.

Operations which had mining activity during part or all of the years 1988 and 1989 were inventoried. Staff visited the planning departments of all lead agencies (counties and cities) with three or more active mines in their jurisdictions. In addition, information was gathered from other state and from federal agencies which interact with the

(28) Livingston Graham sand and gravel mine in the San Gabriel Valley, Los Angeles region. This mine contains a pond extending below the water table. Material is presently being excavated using a barge-mounted chain and bucket dredge system. The sand and gravel are transferred to shore by conveyer belts mounted on pontoons. *Photo by DMG Staff.*

mine operators, as well as from the regional and statewide associations of mineral producers. The SMARA reclamation program files of the Division were also consulted. These data were then merged with existing DMG data files.

Need for Further Outreach and Communication

The file information available from some lead agencies was limited. Field excursions were necessary to confirm the location and commodities being produced. Locations were often incomplete since the MRAP format requires longitude and latitude and Township and Range information so that the properties can be shown on the map accompanying the new active mines report. Local government and mine operators rarely record locations using such information. The cooperation and assistance of lead agencies was key to the success in creating the initial draft of the active mines data base within the time frame ending on March 31, 1989. The canvass has documented the value of expanded future communication between the Division and lead agencies as well as other state and federal government units which interact with mine operators. In order to help lead agencies, DMG plans to assist in the maintenance of their files by providing updates and advice on information management. This will increase the effectiveness of local governments in dealing with mining within their borders and benefit all parties including mine operators.

Outcome of the Survey

The active mines project identified 1,012 active and intermittent mines (extraction during 1988 and/or 1989) in its canvass. There were 319 mines operating without approved reclamation plans and 237 mines had submitted plans and were awaiting approval. Lead agencies have approved approximately 1,030 mined land reclamation plans. As documented in the preliminary inventory completed on March 31, 1989, California mine operators held approximately 1,105 current conditional use permits for mineral extraction in 1988 and 281 mines were operating without use permits. Information about the operational status of some mines was ambiguous. MRAP is working on clarification because it is important for the accuracy of the inventory that all uncertainties be resolved. At the fiscal year's end, the initial active mines list and its accompanying location map at a scale of 1:1,000,000 (one inch equals approximately 16 miles) was being cross-checked with individual mining companies, associations of mine operators and lead agencies.

The intent is to use the initial active mines database as a framework for future inventories. The active mine information is being merged with DMG MRAP files containing earlier data about mining activities, inactive mines and mineral prospects in order to produce MINEFILE, which is a comprehensive list of all mineral occurrences in the state.

A publication is being prepared that presents the active mine information by type of mineral commodity, county and municipal lead agencies, and by company name. This permits accessing information more easily, depending upon interest and initial data available to the user. The 1:1,000,000-scale map (1 inch equals about 16 miles) accompanying the active mines text has many uses. As a wall map, it will provide a synoptic view of the types of mining and the locations of mining within the state.

The Division of Mines and Geology has completed a milestone canvass and is pledged to achieve greater communication between lead agencies, the State and federal governments and mineral producers in the future in order to keep up-to-date records about the status of mining activities as efficiently as possible. The information about mines which are being operated without use permits or without reclamation plans can be used to achieve greater compliance with the SMARA requirements.

PRUDENT POLICIES REGARDING CALIFORNIA'S MINERAL ENDOWMENT

Mineral Resource Opportunities

The old expression "gold is where you find it" states a fundamental principle — economically important minerals are scarce and exist only in certain areas. The search for gold stimulated the state's early development, and mineral development continues to be an important part of California's productivity. As mentioned in other sections of this report, the state leads the nation in the value of its non-fuel mineral economy (1988).

Responses to Opportunities

Five generations after the gold rush, the California Legislature passed the Surface Mining and Reclamation Act to deal with two important contemporary social priorities. The reclamation program aspects of SMARA deal with environmental protection and have already been described in "New Land Uses for Old" and "Regulation of California Mining Waste" discussions in this report. The other priority of SMARA is the assurance of future mineral availability. Land use planning and decision-making should take into account the fact that usable mineral deposits exist only in certain areas. California has pioneered the implementation of public policy regarding the conservation of potentially usable mineral deposits.

In California, the permitting of residential, commercial and industrial land uses including mining is the prerogative of local, county and municipal governments. This arrangement, which is a fundamental part of the State's constitution, keeps the authority over how land is used close to the local constituencies most affected by the decisions. Just as the SMARA reclamation element requires local government to institute the review and approval process for plans submitted by mine operators, the mineral conservation element of SMARA requires that lead agencies consider preserving mineral availability as an option when they are addressing land use applications that are incompatible with surface mining.

DMG Mineral Resource Classification

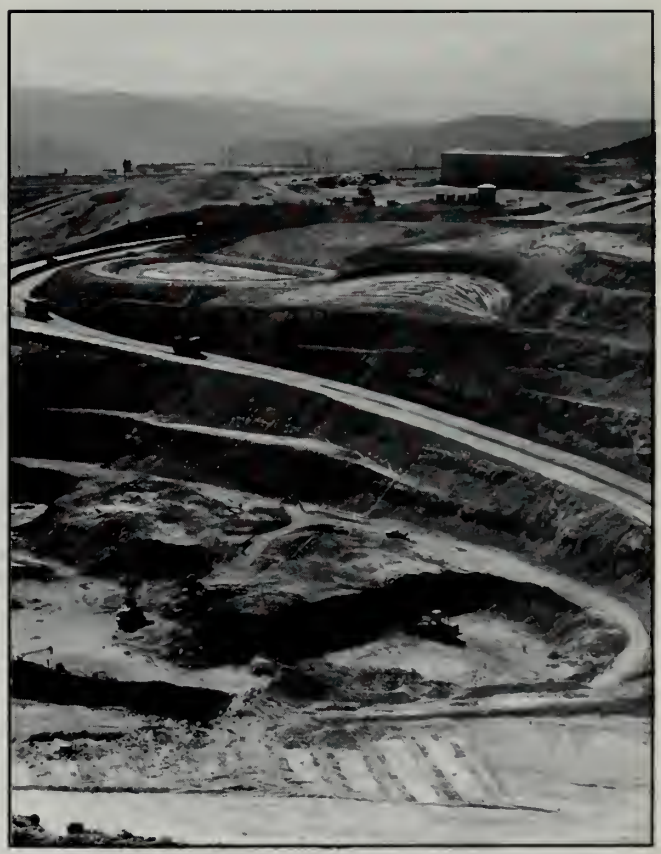
In order for local governments to be aware of the impacts of specific land use decisions on mineral availability, it is necessary for the lead agencies to know the mineral potentials of the parcels in question. In order to provide these insights, SMARA charges the Division of Mines and Geology with the assessment of mineral potential throughout the state by conducting mineral land classification inventories. The State Mining and Geology Board has the responsibility to formally convey this information to lead agencies and to "designate" those mineral resource areas for which the future availability is of "statewide importance." DMG's data are used in the local government deliberations. Under SMARA, lead agencies are required to especially consider designated areas in their general land use plans and in their decision-making.

The State Mining and Geology Board has defined four categories of Mineral Resource Zones (MRZs) which DMG uses in its mineral land classification. The types of zones are:

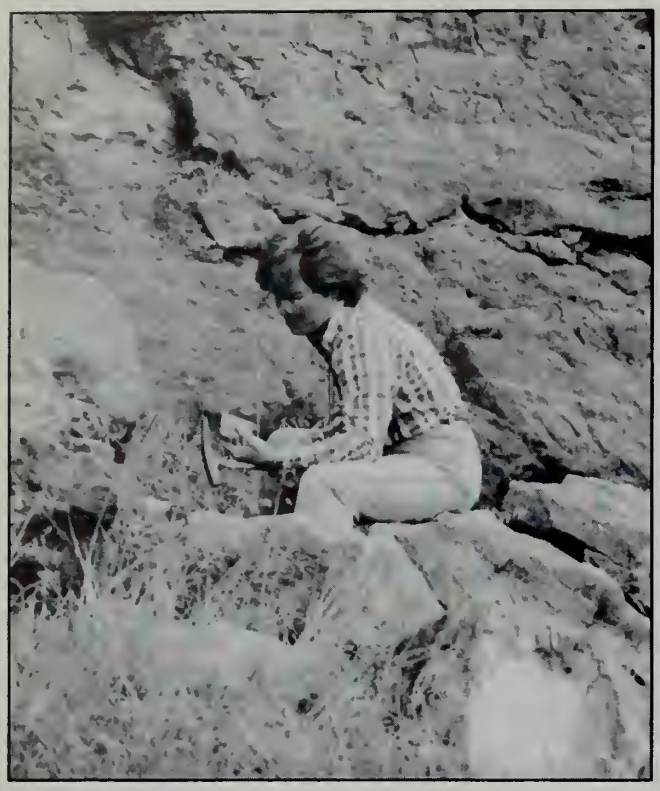
MRZ 1: Areas that *do not* have a potential for a specific mineral commodity occurrence based upon DMG's assessment of the geologic character of these regions.

MRZ 2: Areas that *do* have a potential for a specific mineral commodity occurrence based upon DMG's assessment of the geologic character of these regions.

MRZ 3: Areas that *may* have a potential for specific mineral commodity occurrence based upon DMG's assessment of the geologic character of these regions.



(29) View of a portion of the pit at the McLaughlin Gold Mine. *Photo by J. Burnett, DMG Staff.*



(30) Mineral classification requires DMG geologists to observe the geology of their study area as it is exposed at the surface. *Photo by DMG Staff.*

MRZ 4: Areas for which the existing available geologic data permits *no conclusion* about whether or not the region may possess a significant potential for a specific mineral commodity occurrence.

History of Classification

During the implementation of the mineral classification element of SMARA in the late 1970's, the Mining Board specified that the assessment of construction aggregates, including sand, gravel and crushed stone, within urbanizing areas of the state be given first priority. Work was begun in both southern and northern California metropolitan areas. Reports were developed for "production and consumption regions," within which mining was taking place and the mineral products were being used. Maps showing MRZ 2 areas of known sand and gravel or crushed stone potential were prepared and printed at the scale of 1:48,000 (one inch equals 0.8 miles). The MRZ 2 zones were evaluated for approximate tonnage potential in areas termed MRZ sectors. The Board also required that DMG determine the need for the product within the production/consumption region during the next 50 years. DMG found that there is a statistically valid historical correlation between population and aggregate consumption in these production/consumption regions. This allows future consumption to be projected on the basis of federal population forecasts. The Board used both the future need and the MRZ 2 tonnage estimates in deciding which sectors to designate as being of "statewide" importance.

By 1989 all of the largest metropolitan areas covering an area of about 22,000 square miles (see Figure 5) had been classified by DMG for construction aggregate commodities, and the Board had designated local areas of statewide significance within most of them.

In response to legislative expansion of the DMG classification project in 1980, DMG undertook to classify the non-urban areas within the highly mineralized California desert and the rapidly growing Sierra Nevada Foothill counties on the west side of the Great Valley in central and northern California. The emphasis in the rural areas was on industrial mineral and metal resources rather than sand and gravel. Figure 7 presents the areas classified in the desert covering about 5,000 square miles and Figure 6 illustrates the status of classification of about 2,000 square miles in the Sierra Nevada Foothills.

The non-urban classification areas for which reports were developed consisted of groups of 7 1/2- and 15-minute topographic quadrangles published at scales 1:48,000 (1 inch equals 4,000 feet, about 0.8 mile) and 1:62,000 (1 inch equals about 1 mile).

1988-89 Innovations in Classification Procedures

After over 10 years of experience in mineral resource classification, the Mining and Geology Board, and the Department of Conservation's Division of Mines and Geology considered ways classification procedures could be modified in order to provide mineral potential insights more rapidly and efficiently.

In response, DMG staff evaluated the usefulness of four possible modifications to future classification strategy:

- whether or not urban classification should continue to be done by production/consumption areas or by entire counties and whether non-urban classification should continue to map contiguous groups of 15-minute topographic quadrangles, or entire counties;
- whether the DMG should combine its urban and non-urban classification staffs and use the single group to classify all types of mineral commodities in an area at one time;
- whether less detail should be gathered in classification studies and whether commensurate reductions should be made in the map scales used in the assessment of the mineral resource potential; and

Progress of Classification–Designation Program

Index map of California, showing location and status of mineral land classification study areas being classified and/or designated in the Urban SMARA Program as of June 30, 1989.

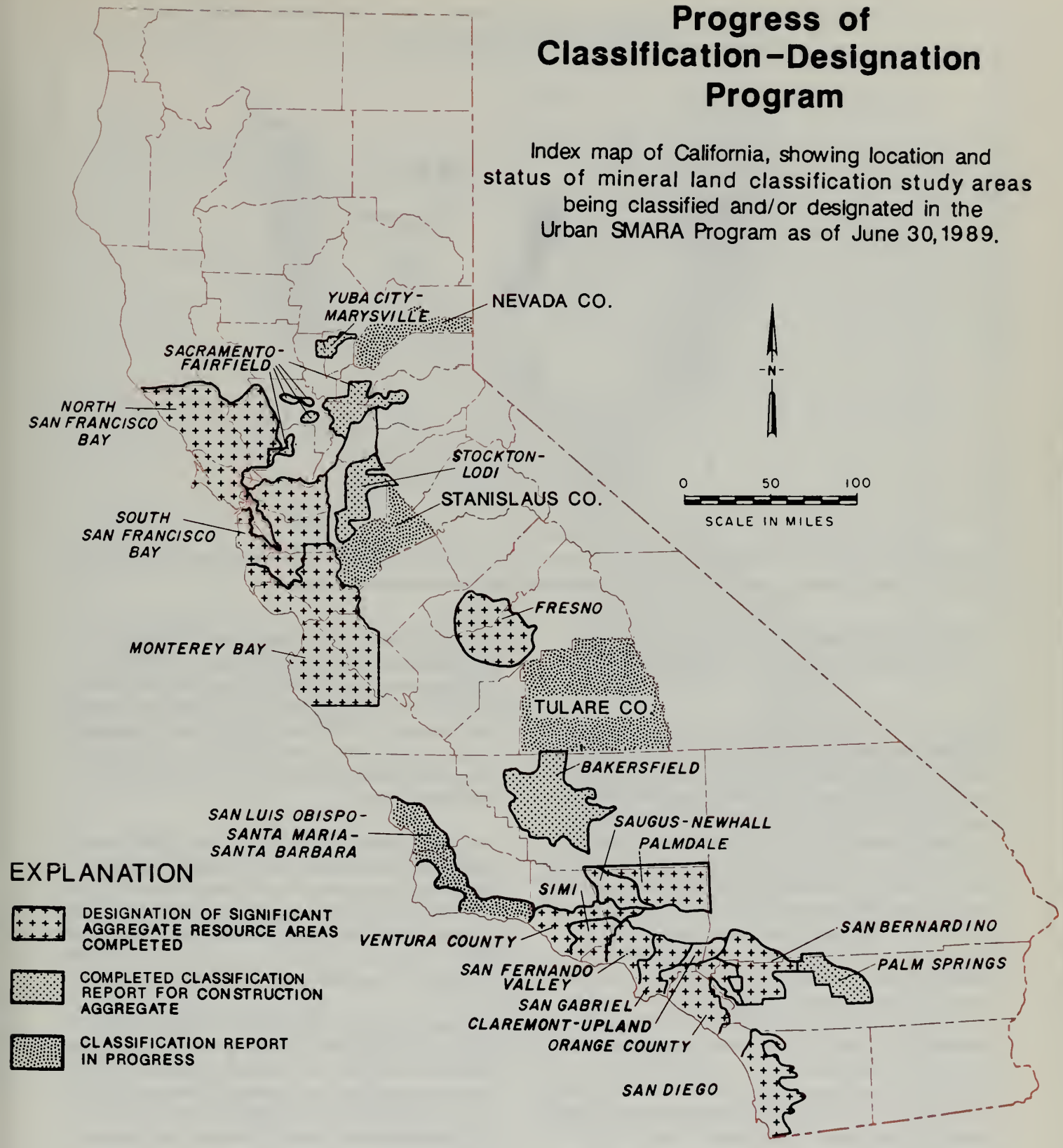


Figure 5. Status of Urban SMARA Classification-Designation Project, June 30, 1989.

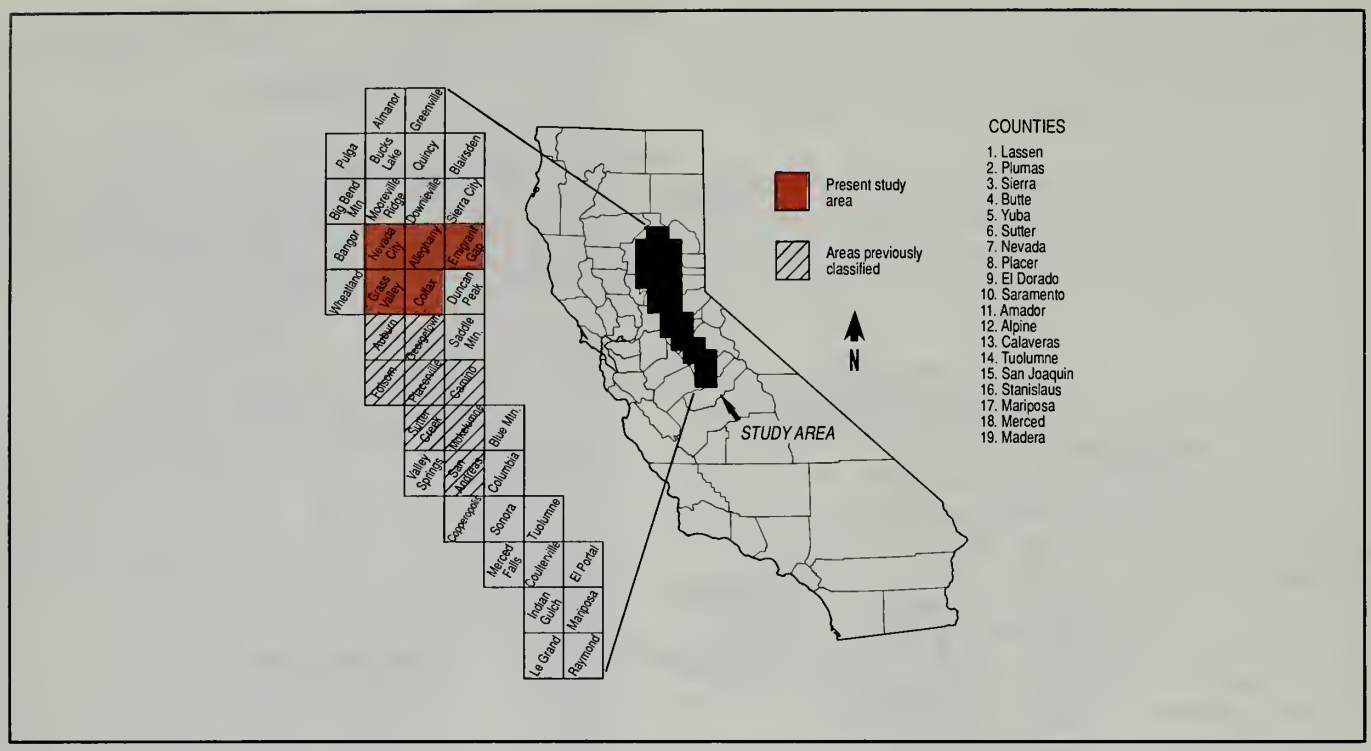


Figure 6. 15-minute quadrangle index map of Sierra Nevada metamorphic belt mineral land classificaton.

- whether changes should be made in the priorities used in scheduling future areas to be classified.

Based on DMG recommendations, the Board has decided that entire counties will be classified at one time in the future. This arrangement will produce maps and reports which encompass significantly larger areas than the aggregate production/consumption areas. To be practical, it will be necessary to produce county classification reports with considerably less time spent for each square mile covered. Large counties may be divided into two sections. For sand and gravel studies, time can be saved if the volume of aggregate material in sectors is not estimated as has been previously required by the Board. DMG now plans to merge the activities of the urban and non-urban classification units. They will make a single pass through a county, classifying all types of mineral commodities at one time. This approach will yield maps and reports that present all of the mineral potential of a county in one document. To accommodate the large area encompassed in each county report and the shorter preparation time, the number of maps and the detail of the information that is presented will be reduced. Plans are to continue the 1:48,000 map scale for aggregates and 1:62,500 for other commodities. Staff compilation of field data will also continue at the scales of 1:24,000 or 1:62,500.

The priority areas for the classification program have been reappraised to reflect the change to the whole-county approach and the integration of the two classification activities. The Board has requested that the classification in Fiscal Year 1989-90 be undertaken to complete Nevada County in the Sierra Foothills and begin classification in the western portions of Riverside and San Bernardino counties.

This classification innovation will reduce DMG costs of report preparation because only one report rather than several will be required for each county and only one distribution will take place. County governments will save because they will only have to modify their general plans once in order to accommodate the information contained in the single classification reports each will receive.

As Fiscal Year 1988-89 drew to a close, the SMARA classification staff were organizing their activities around these new directives. It is expected that these modifications in the classification process will increase the timeliness and usefulness of the published products to local governments as part of the Division and the Department's communication and outreach efforts.

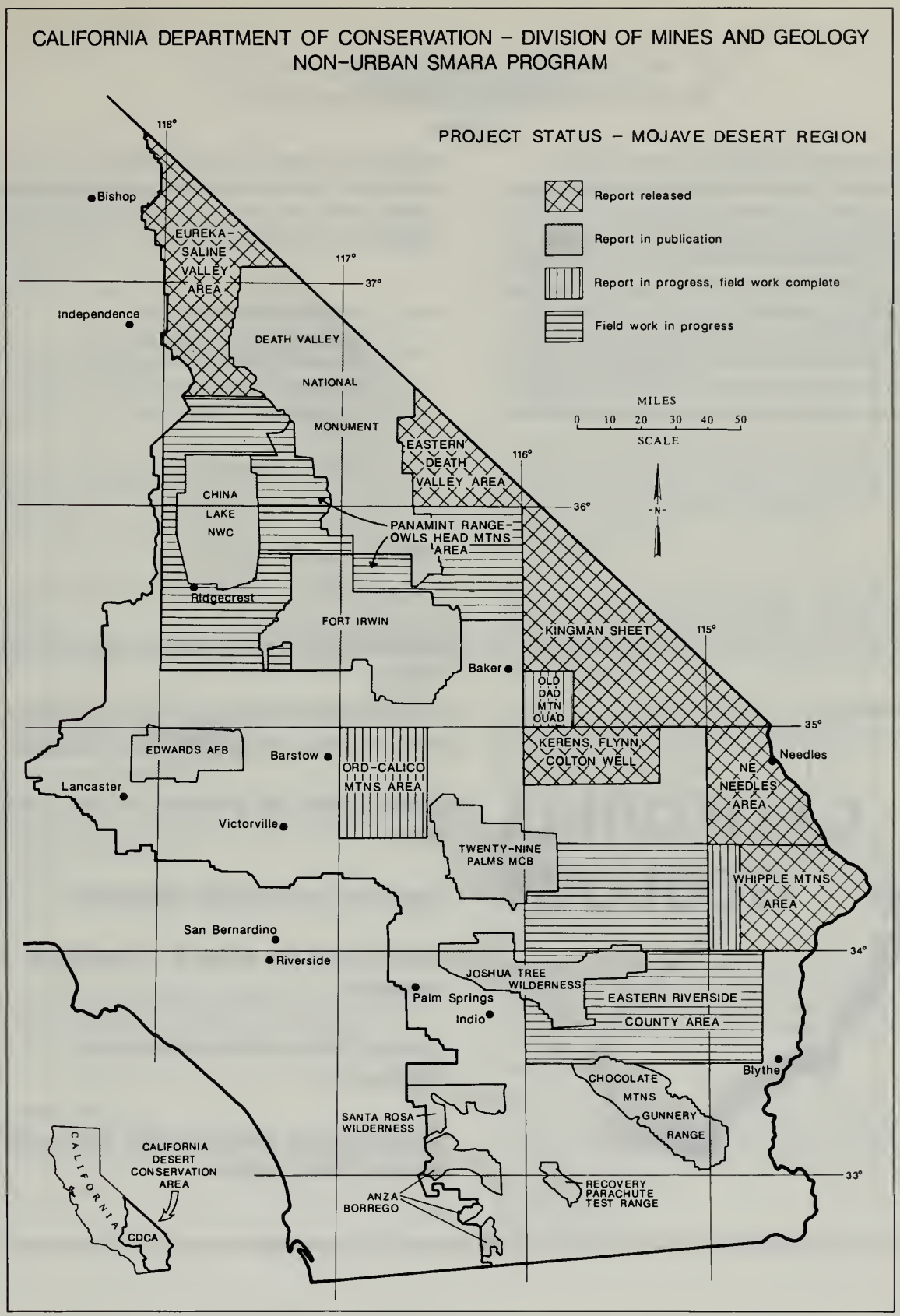


Figure 7. Status of classification in the desert region of southeastern California.

CONCLUSION

The Division of Mines and Geology is responding to California's unique combination of challenges and opportunities by expanding its outreach to the diverse users of its products and services. In 1988-89 DMG undertook initiatives that will affect both seismic safety and mineral policy in California. DMG has placed increased emphasis on communication, particularly in the form of expanded advisory services to other State and local government agencies, the scientific and mining communities, and the public. DMG is pledged to continue these efforts during the years ahead. It is hoped that this report will stimulate suggestions to DMG regarding additional ways in which we can serve the citizens of California during the administration of our programs. Please send comments and suggestions to the address below:

California State Geologist
Department of Conservation
Division of Mines and Geology
1416 Ninth Street, Room 1341
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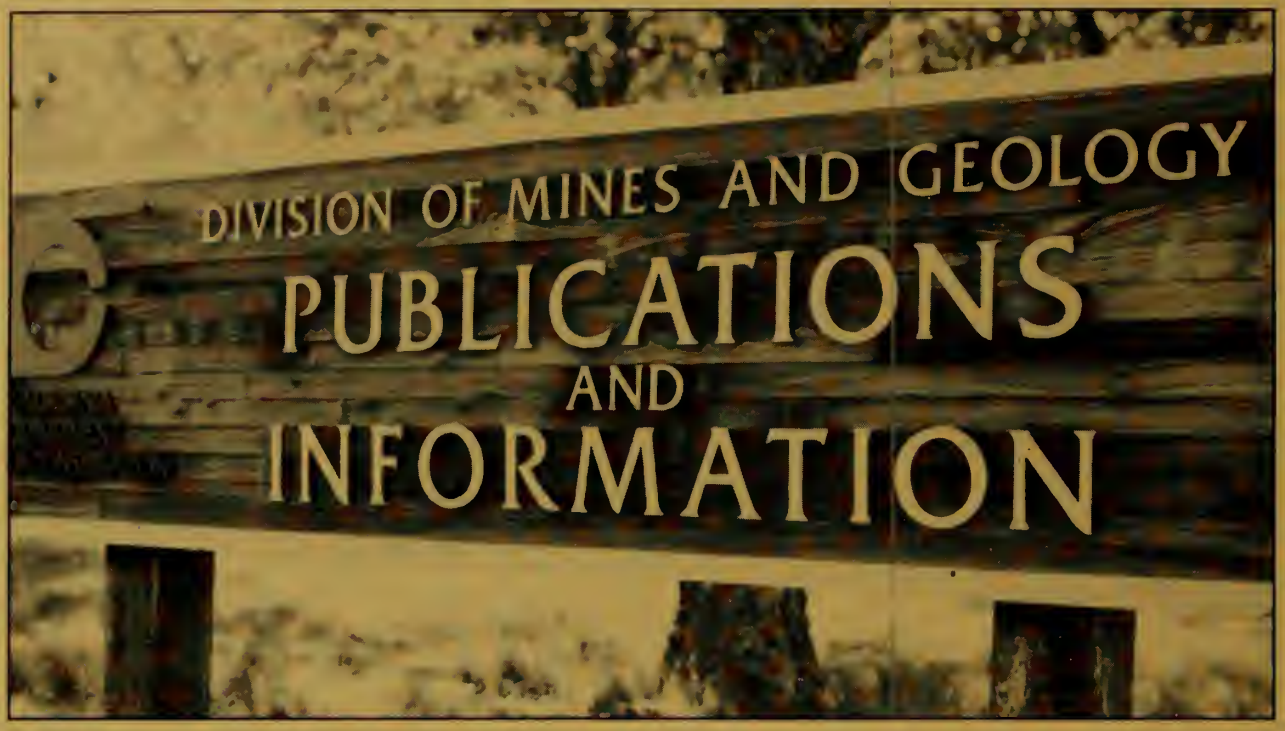

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